

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
H05B 33/20

A1

(11) International Publication Number: WO 98/02019

(43) International Publication Date: 15 January 1998 (15.01.98)

(21) International Application Number: PCT/IB96/00665

(22) International Filing Date: 10 July 1996 (10.07.96)

(71) Applicant: INTERNATIONAL BUSINESS MACHINES CORPORATION [US/US]; Old Orchard Road, Armonk, NY 10504 (US).

(72) Inventors: BIEBUYCK, Hans; Mythenstrasse 8, CH-8800 Thalwil (CH). HASKAL, Eliav; Idastrasse 7, CH-8003 Zurich (CH).

(74) Agent: HEUSCH, Christian; International Business Machines Corporation, Säumerstrasse 4, CH-8803 Rüschlikon (CH).

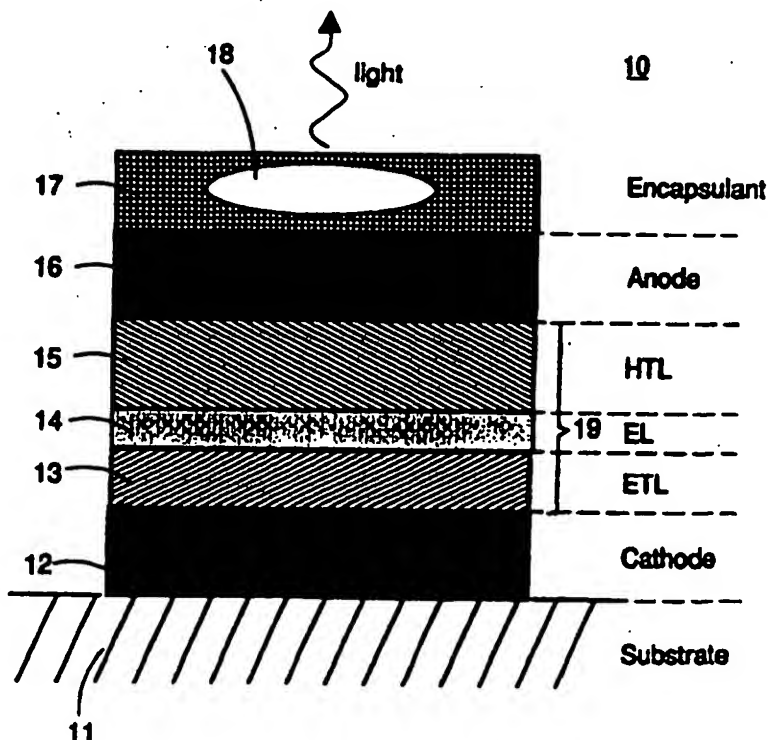
(81) Designated States: IL, JP, KR, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: SILOXANE AND SILOXANE DERIVATIVES AS ENCAPSULANTS FOR ORGANIC LIGHT EMITTING DEVICES

(57) Abstract

An organic light emitting device (10) is provided which is encapsulated by a Siloxane film (17). This Siloxane film (17) is applied to the light emitting portion of the diode (10) providing for protection against contamination, degradation, oxidation and the like. The Siloxane film (17) carries an optical element, such as a lens (18) for example. This optical element (18) is arranged such that the light generated inside the diode (10) is output through it.



BEST AVAILABLE COPY

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

1

DESCRIPTION

5

**Siloxane and Siloxane Derivatives as Encapsulants for
Organic Light Emitting Devices****TECHNICAL FIELD**

10 The present invention pertains to organic electroluminescent devices, such as discrete light emitting devices, arrays, displays, and in particular to the encapsulation of these devices. It furthermore relates to a method for encapsulating the same.

15

BACKGROUND OF THE INVENTION

Organic electroluminescence (EL) has been studied extensively because of its possible applications in discrete light emitting devices, arrays and displays. Organic materials investigated so far can potentially replace
20 conventional inorganic materials in many applications and enable wholly new applications. The ease of fabrication and extremely high degrees of freedom in organic EL device synthesis promises even more efficient and durable materials in the near future which can capitalize on further improvements in device architecture.

25

Organic EL light emitting devices (OLEDs) function much like inorganic LEDs. Depending on the actual design, light is either extracted through a transparent electrode deposited on a transparent glass substrate, or through a transparent top electrode. The first OLEDs were very simple in
30 that they comprised only a two to three layers. Recent development led to organic light emitting devices having many different layers (known as multilayer devices) each of which being optimized for a specific task.

1 With such multilayer device architectures now employed, a performance
limitation of OLEDs is the reliability. It has been demonstrated that some of
the organic materials are very sensitive to contamination, oxidation and
humidity. Furthermore, most of the metals used as contact electrodes for
5 OLEDs are susceptible to corrosion in air or other oxygen containing
environments. A Ca cathode, for example, survives intact only a short time
in air, leading to rapid device degradation. It is also likely that such highly
reactive metals undergo a chemical reaction with the nearby organic
materials which also could have negative effects on device performance. A
10 low work function cathode metal approach requires careful handling of the
device to avoid contamination of the cathode metal, and immediate, high
quality encapsulation of the device if operation in a normal atmosphere is
desired. Even well encapsulated low work function metal contacts are
subject to degradation resulting from naturally evolved gases, impurities,
15 solvents from the organic LED materials.

Many approaches have been attempted in order to solve the problem of
electrode instability and degradation. A common approach is the use of a
low work function metal subsequently buried under a thicker metal coating.
20 In this case, pinholes in the metal still provide ample pathways for oxygen
and water to reach the reactive metal below, as is described in Y. Sato et
al., "Stability of organic electroluminescent diodes", *Molecular Crystals and
Liquid Crystals*, Vol. 253, 1994, pp. 143-150, for example.

25 The overall lifetime of current organic light emitting devices is limited. The
lack of inert, stable, and transparent encapsulants for stable OLED operation
remains a major obstacle to OLED development.

Organic LEDs have great potential to outperform conventional inorganic
30 LEDs in many applications. One important advantage of OLEDs and devices
based thereon is the price since they can be deposited on large,
inexpensive glass substrates, or a wide range of other inexpensive
transparent, semitransparent or even opaque crystalline or non-crystalline

1 substrates at low temperature, rather than on expensive crystalline
substrates of limited area at comparatively higher growth temperatures (as
is the case for Inorganic LEDs). The substrates may even be flexible
enabling pliant OLEDs and new types of displays. To date, the performance
5 of OLEDs and devices based thereon is inferior to inorganic ones for
several reasons:

1. High operating current: Organic devices require more current to
transport the required charge to the active region (emission layer)
10 which in turn lowers the power efficiency of such devices.

2. Reliability: Organic LEDs degrade in air and during operation. Several
problems are known to contribute.

A) Efficient low field electron injection requires low work function
15 cathode metals like Mg, Ca, Li etc. which are all highly reactive in
oxygen and water. Ambient gases and impurities coming out of the
organic materials degrade the contacts.

B) Conventional AgMg and ITO contacts still have a significant
barrier to carrier injection in preferred ETL and HTL materials,
20 respectively. Therefore, a high electric field is needed to produce
significant injection current.

3. Poor chemical stability: Organic materials commonly used in OLEDs are
vulnerable to degradation caused by the ambient atmosphere, diffusion
25 of contact electrode material, interdiffusion of organics, and reactions of
organics with electrode materials.

As can be seen from the above description there is a need for simple and
efficient encapsulation of organic light emitting devices. It is a further
30 problem of light emitting devices in general, that a light path for emission of
the light generated is to be provided.

1 It is an object of the present invention to provide a simple and cheap encapsulation of organic light emitting devices.

It is a further object of the present invention to provide new and improved
5 organic EL devices, arrays and displays based thereon with improved stability and reliability.

It is a further object to provide a method for making the present new and improved organic EL devices, arrays and displays.

10

15

20

25

30

SUMMARY OF THE INVENTION

1 The invention as claimed is intended to improve the reliability of known organic light emitting devices. The above objects have been accomplished
5 by providing a transparent Siloxane or Siloxane derivative encapsulation for an organic light emitting device. The encapsulant comprises an optical element being arranged such that it lies within the light path of the light emitted by said organic light emitting device. Examples of optical elements that may be formed in, or embedded by the encapsulant are: lenses, filters,
10 color converters, gratings, prisms and the like.

The present invention builds on the finding that Siloxanes and Siloxane derivatives are well suited for use in direct contact with the organic materials used for making organic light emitting devices. This is in contrast
15 to currently accepted OLED technology, where no material is allowed to come into direct contact with the organic device. Current OLEDs are protected by 'mechanical' sealing, e.g. using an appropriate housing and sealing means.

20 In contrast to conventional approaches, the encapsulant is also allowed to cover the light emitting portion(s), or part thereof. It turned out that Siloxanes and Siloxane derivatives do not seem to have a detrimental impact on the behavior and lifetime of the light emitting portion of organic devices.

25 The Siloxanes and Siloxane derivatives form a transparent and non-reactive seal which makes conformal contact with the organic devices. It provides for an excellent barrier to external contamination, such as water, solvent, dust and the like. The proposed encapsulant also protects against corrosion
30 of the highly reactive metal electrodes (e.g. calcium, magnesium, lithium) used in OLED devices. It is non-conductive, which is of particular importance in case that metal electrodes are also embedded in the encapsulant.

1 Furthermore, Siloxane and Siloxane derivatives are extremely robust and
stable. They are unlikely to react with the organic devices even in
high-driving, high-heating conditions. Even close to the light emitting
portion(s) of OLEDs, where usually the power density has its maximum, no
5 reaction with the present encapsulant takes place.

It is another important feature of Siloxane and Siloxane derivatives that it
forms a conformal contact with the underlying organic material such that no
air, solvent, or water is trapped. Due to this, the lifetime of the organic
10 device is extended.

Further advantages of the Siloxane and Siloxane derivative encapsulation
will be addressed in connection with the embodiments of the present
invention.

15

20

25

30

DESCRIPTION OF THE DRAWINGS

The invention is described in detail below with reference to the following schematic drawings (It is to be noted that the drawings are not drawn to scale):

FIG. 1 shows a schematic cross-section of a discrete organic light emitting device being protected by a Siloxane encapsulant comprising an optical element, according to the present invention.

FIG. 2 shows a schematic cross-section of a Siloxane encapsulant, according to the present invention, comprising a pocket-like portion carrying a lens.

FIG. 3 shows a cross-section of a display or array, according to the present invention, comprising two Siloxane layers serving as encapsulants.

FIG. 4 shows a top-view of a display or array, according to the present invention, comprising a Siloxane film having a matrix of lenses.

FIG. 5 shows a top-view of a conventional display or array.

FIG. 6 shows a top-view of the display or array of Figure 5, comprising a Siloxane film having a pathways filled with color conversion dyes, according to the present invention.

FIG. 7A-C illustrates the fabrication of a Siloxane film, according to the present invention.

GENERAL DESCRIPTION

Silicone molding compounds have been known for more than twenty years and their uses include, among others, the encapsulation of electrical and electronic devices. In particular Siloxane, a silicone resin, is widely used for the molding of electronic devices, such as integrated circuits, and the coating of portions of such devices. Typical examples of Siloxanes are composed of copolymers or blends of copolymers of any combination of monophenylsiloxane units, diphenylsiloxane units, phenylmethylsiloxane units, dimethylsiloxane units, monomethylsiloxane units, vinylsiloxane units, phenylvinylsiloxane units, methylvinylsiloxane units, ethylsiloxane units, phenylethylsiloxane units, ethylmethylsiloxane units, ethylvinylsiloxane units, or diethylsiloxane units.

Depending on the resin composition, the properties of Siloxane can be altered. Some aspects to be taken into account are: stability against crack formation, moisture resistance, coefficient of thermal expansion, elastic modulus and crosslinking methods. Siloxanes that cross link by the hydrosilylation reaction provide a particularly useful subset of Siloxane. Siloxanes allowing crosslinking on their exposure to light, are also preferred as when the Siloxane prepolymer contains vinyl or acetylenic groups and a light activated radical initiator, for example.

Examples of Siloxanes and Siloxane derivatives suited as encapsulants for organic light emitting devices are those given in US patents 4125510, 4405208, 4701482, 4847120, 5063102 and 5213864, 5260398, 5300591, and 5420213, for example. It is important to choose a Siloxane which is transparent in the wavelength range of the light emitted by the OLED to be encapsulated. In the following, the word Siloxane is used as a synonym for all different kinds of transparent Siloxanes. Other materials can be cured with the Siloxane to further enhance a material property. Thus mixtures of two polymers can provide enhancement of the device performance as when one component of the encapsulant contains an oxygen scavenger like an

1 organoplatinum complex or Titanium, or a free radical scavenger like tert
butanol or some similar molecule. Alternatively, the Siloxane also provides
a useful passivation layer for transfer of a second polymer layer, especially
where the latter requires an aggressive solvent that would otherwise attack
5 the device, but is effectively blocked by the Siloxane. This second layer can
further improve performance by preventing passive or active diffusion of
gases through to the OLED.

In order to avoid contamination of the organic stack of the OLED to be
10 encapsulated, or to prevent metal electrodes from corrosion, it turned out to
be important to have an encapsulant which makes conformal contact with
the devices. Furthermore, it is important that the OLED can be encapsulated
without having to heat the OLED or without having to treat it with aggressive
chemicals.

15 Siloxane and Siloxane derivatives can be molded into shapes that can be
put on the OLED easily. Due to the elastic properties of Siloxane, it easily
conforms to the OLED surface. It is possible, to roll a pre-fabricated
Siloxane film onto the OLED. It is an interesting property of Siloxane, that
20 several films of Siloxane can be stacked on each other. Siloxanes are
particularly well suited to molding on the micron and submicron scales
forming stable patterns (structures) with high aspect ratio and facile release
properties.

25 Instead of putting pre-fabricated Siloxane onto the OLED, one may likewise
cover the OLED with a viscous Siloxane composition that can be cured
using ultraviolet radiation, as for example described in US patent 5063102.
If a curable Siloxane composition is used, excessive heating of the OLED is
avoided. This case is particularly desirable for micromolding or embossing
30 where the optical element, e.g. a light bending element, and the encapsulant
are formed on the device in a single manufacturing step.

1 A first embodiment of the present invention is illustrated in Figure 1. A discrete organic light emitting device 10 is shown. It comprises an electrode 12 (cathode) situated on a substrate 11. On top of the electrode 12 a stack of three organic layers 13-15 is situated. The organic layer 13 serves as
5 electron transport layer (ETL) and the organic layer 15 serves as hole transport layer (HTL). The organic layer 14 which is embedded between the two transport layers 13 and 15 serves as electroluminescent layer (EL). In the following, the stack of organic layers will be referred to as organic region, for sake of simplicity. In the present embodiment, the organic region
10 carries the reference number 19. On top of the HTL 15, a top electrode (anode) 16 is formed. The uppermost surface of the device 10 is sealed by a Siloxane film 17. This film 17 conforms to the device 10. In the present example, the optical element embedded in the encapsulant 17 is a lens 18. Siloxane may also be used to cover and protect cathode-up structures.

15 Such a lens 18 can be a discrete optical element, which is embedded in the encapsulant 17 (as shown in Figure 1). Likewise, a lens 20 may be placed in a pocket-like section 21 of an encapsulant 22, as schematically illustrated in Figure 2. In order to further simplify the packaging and in order to
20 reduce the costs, a lens might be directly formed in the Siloxane by means of embossing, for example (see Figure 3). Here a second layer of Siloxane with a higher refraction index can be added to enhance the lensing.

A second embodiment is illustrated in Figure 3. In this Figure, a
25 cross-section of an organic light emitting array 30 is shown. On top of a common substrate 31, cathodes 32 are patterned such that each of the light emitting diodes of the array 30 can be individually addressed. For sake of simplicity, the organic light emitting diodes are depicted as a dark grey layer 33. The layer 33 may comprise a stack of organic layers, for example.
30 On top of the organic layer 33, a transparent or semi-transparent anode 34 is formed. In order to planarize the array 30, a curable Siloxane encapsulant is poured over the top of the array. By exposure of the

1 Siloxane to ultraviolet light, a thin Siloxane layer 35.1 is formed. This layer
35.1 encapsulates the array 30 and provides for a planarized top surface.

5 In a next step, a Siloxane film 35.2, comprising embossed lenses 36, is
applied. This Siloxane film 35.2 may for example be rolled onto the array 30.
The Siloxane film 35.2 and the Siloxane layer 35.1 adhere to each other.
The lenses 36 are aligned to the diodes of the array 30 such that light
emitted by the diodes passes through the anode 34, the Siloxane 35.1 and
35.2 and the lenses 36 before being emitted into the halfspace above the
10 array 30. In the present arrangement, the size of each of the diodes of the
array 30 is mainly defined by the shape of the cathodes 32. It is to be
noted, that the present invention is also suited for cathode-up structures.

15 In Figure 4, another embodiment is illustrated. Shown is the top view of an
organic display 40. Only the uppermost layer 43 of this display 40 is visible
in Figure 4. The display 40 comprises 9x5 rectangular pixels 41. Part of the
display's surface is covered and encapsulated by a Siloxane film 44. The
Siloxane film 44 carries a matrix of lenses 42. The film 44 is laterally
aligned such that the lenses 42 are aligned with respect to the pixels 41
20 such that light is emitted through the lenses 42. Either micro or macro
lenses may be employed to improve the directionality of the light emitted, or
to focus the light. Focussing is for example required in a head mounted
display. A Siloxane film with macro lenses could be applied to a
conventional organic light emitting display to focus the light of the display
25 on the viewer's eye(s). A Siloxane film with integrated optical elements,
according to the present invention, eliminates the need for separate optics
and combines the encapsulant with essential device operational items. It
can be aligned with respect to the organic device underneath, using an
alignment scheme as described in the co-pending PCT patent application
30 "Stamp for a Lithographic Process", application number PCT/IB95/00609,
filed on 4 August 1995, for example.

1 Another organic display embodiment 50 is illustrated in Figure 5. As in
Figure 4, only the uppermost layer 55 of the display 50 is shown. The
display comprises 9 columns and 11 rows of rectangular pixels 51. The
display 50 is designed such that each pixel 51 emits white light if driven
5 accordingly. In order to realize a multicolor display, usually color filters or
color converters are employed. According to the present invention, no
photolithographic steps with undesired chemicals are needed. In certain
cases, photolithography can not be avoided for the definition of optical
elements. In such a case, one may deposit or form a Siloxane
10 encapsulation, before the photolithographic steps are carried out. This
Siloxane layer then protects the organic device from the aggressive
chemical photolithographic steps that may compromise the device. An
appropriate color converter placed on top of the display 50 is illustrated in
Figure 6. Optical elements 53, 54 serving as color converters are integrated
15 into a Siloxane film 52. Pathways 53 and 54 are provided in the Siloxane
film 52 by micromolding or embossing the Siloxane. The depth of the
pathways is designed around the color conversion material, but is typically
in the range of 0.1 to 50 μm , and preferably between 1 and 15 μm . Instead
of pathways, containers can be formed within the Siloxane which may have
20 almost any form and size. The pathways 53 contain a first color converting
dye and the pathways 54 contain another color converting dye. In the
present example, the Siloxane film 52 is placed on top of the display 50
such that the first, fourth and seventh column of pixels is aligned to the
pathways 53. The second, fifth and eighth column of pixels is aligned to the
25 pathways 54. By choosing appropriate color converting dyes, a three-color
display can be realized.

Such color converters can be easily made, as briefly described in the
following. In Figure 7A, a the Siloxane film 52 is shown which comprises a
30 first set of pathways 53 and a second set of pathways 54. In order to fill the
first set of pathways 53 with a color conversion dye giving green light, for
example, one edge of the Siloxane film 52 may be dipped into a bath 70
comprising a suited dye, as shown in Figure 7B. The dye is now

1 automatically loaded into the pathways 53 by capillary action. If the first set
of pathways 53 is filled, the Siloxane film 52 is flipped and the opposite edge
is dipped into another bath 71 comprising another dye. By sealing the
capillary opening with Siloxane, for example, the dye(s) can remain in a
5 solution state, further enhancing spectral performance and efficiency of the
color conversion dye. Likewise, one may allow the liquid to evaporate
leaving the solid dye confined. By doing so, the second set of pathways 54
is filled with the dye contained in the second bath 71 (see Figure 7C). The
second dye may be a dye giving red. The dyes can remain a liquid within
10 the pathways provided in the Siloxane film 52, or its solvents can drain
away leaving the dye behind in a solid state.

By means of the above approach, a blue emitting organic array 50 may be
patterned by red and green color converters thereby giving a full-color RGB
15 (red, green, blue) display, as shown in Figure 6.

A Siloxane film or encapsulant can be easily mass-fabricated. The
respective fabrication steps can be carried out independently without having
a detrimental effect on the more complicated OLED device.
20

Over a broad sheet of organic light emitters, patterns in a Siloxane film may
be filled with color conversion dyes by capillary action so as to form
multicolor static images. These images may be modified by replacement of
the patterned Siloxane film with the encapsulated dye, or by a micro-fluidic
25 manipulation of the color conversion dyes in the Siloxane pattern. The
pathways in the Siloxane film are filled with immiscible liquids, each filled
with a dye corresponding to the desired color. These pathways can then be
filled or emptied by approximate application of pressure, or other means
that causes the liquid to flow in or out of the pathways.
30

Depending on the composition and thickness of the Siloxane used, a flexible
encapsulant can be obtained. Such a flexible encapsulant can be applied to
organic light emitting devices being formed on a flexible substrate. It is

1 possible, for instance, to realize flexible organic displays being protected by
a flexible encapsulant.

5 Examples of optical elements that may be formed in, or embedded by the
encapsulant are: lenses, filters, color converters, gratings, diffusers,
polarizers, and prisms just to mention some examples. A mixture of color
converters and attenuators may be brought into contact with, or formed on
top of an organic multi-color light emitting array, in order to compensate
10 for unequal efficiency of the light generation at different wavelengths. It is
also feasible to form a Siloxane film comprising trapped bubbles. These
bubbles serve as optical elements which interact with the light emitted by
the OLED underneath. A lens can be easily formed by providing an empty
bubble of well defined size and shape within the Siloxane. This can for
15 example be achieved by embedding a sample of the respective size and
shape in Siloxane. An appropriate sample should be chosen such that it
can be easily removed later. It is conceivable to remove it using an etchant,
or by solving it in a suitable solvent. Likewise, it may be removed
mechanically.

20 To summarize, the above exemplary embodiments are fully compatible with
any kind of organic light emitting devices, including polymeric, oligomeric,
and small molecule OLED designs, or any hybrid design thereof.

25

30

CLAIMS

1. Organic light emitting device having
 - a) two contact electrodes, one thereof serving as anode and the other one serving as cathode, and
 - b) an organic region in which light is generated by means of electroluminescence if a voltage is applied between said two contact electrodes,being characterized in that at least part of the light emitting portion is covered by Siloxane, said Siloxane comprising an optical element being arranged within the path of said light.
2. The organic light emitting device of claim 1, wherein said Siloxane is either a Siloxane film applied to said light emitting portion, or curable Siloxane cured on said light emitting portion.
3. The organic light emitting device of claim 1, wherein said organic region is an organic multilayer structure.
4. The organic light emitting device of claim 1, wherein said Siloxane is in direct contact with one of said contact electrodes and/or said organic region.
5. The organic light emitting device of any of the preceding claims, wherein said optical element is a lens, filter, color converter, grating, diffuser, polarizer, or prism, or any combination thereof.
6. The organic light emitting device of claim 5, wherein said optical element is either
 - embedded in said Siloxane, or
 - formed in said Siloxane, or
 - placed in a pocket-like portion of said Siloxane.

- 1 7. The organic light emitting device of claim 1, wherein said organic light emitting device is an array or display.
- 5 8. The organic light emitting device of claim 7, wherein said Siloxane comprises an array or matrix of optical elements each being aligned to the corresponding light emitting diodes of said array or being aligned to the pixels of said display.
- 10 9. The organic light emitting device of claim 8, wherein said optical element is a color conversion element or color filter realized by a suited dye contained in said Siloxane.
- 15 10. The organic light emitting device of claim 9, wherein said dye is filled into container(s), preferably pathway(s), formed in said Siloxane.
- 20 11. Siloxane film for protection of part of the light emitting portion of an organic light emitting device having
- 25 a) two contact electrodes, one thereof serving as anode and the other one serving as cathode, and
- b) an organic region in which light is generated by means of electroluminescence if a voltage is applied between said two contact electrodes,
- said Siloxane film being characterized in that it comprise an optical element designed to interact with light emitted by said organic light emitting device.
- 30 12. The Siloxane film of claim 11, wherein said optical element is a lens, filter, color converter, grating, prism, diffuser, or polarizer, or any combination thereof.
13. The Siloxane film of claim 11, wherein said optical element is either
- embedded in said Siloxane film, or
 - formed in said Siloxane film, or

- 1 • placed in a pocket-like portion of said Siloxane film.
14. The Siloxane film of claim 11, comprising an array or matrix of optical elements.
- 5 15. The Siloxane film of claim 8, wherein said optical element is a color conversion element or color filter realized by a suited dye contained in said Siloxane film.
- 10 16. The Siloxane film of claim 15, wherein said dye is filled into container(s), preferably pathway(s), formed in said Siloxane.
17. The Siloxane film of claim 16, wherein said dye contained in said container(s) is either in its liquid state or in its solid state.
- 15 18. Method for making a Siloxane film for protection of part of the light emitting portion of an organic light emitting device, said Siloxane film having color conversion elements or color filters, said method comprising the steps of
- 20 • forming containers in said Siloxane film, and
- filling said containers with a dye, preferably a color conversion dye.
- 25
- 30

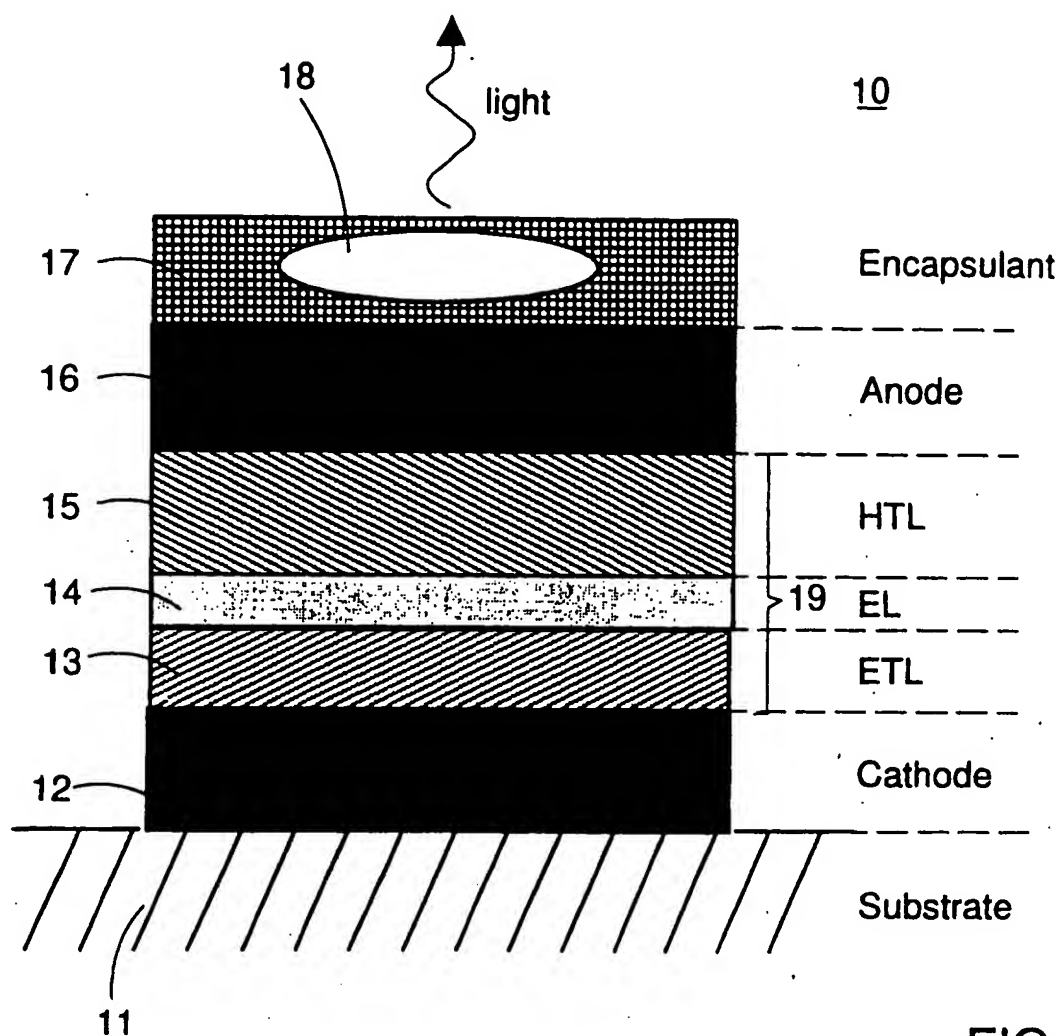


FIG. 1

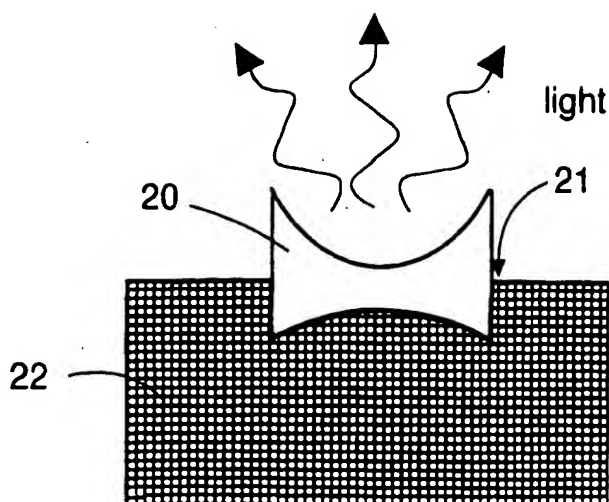


FIG. 2

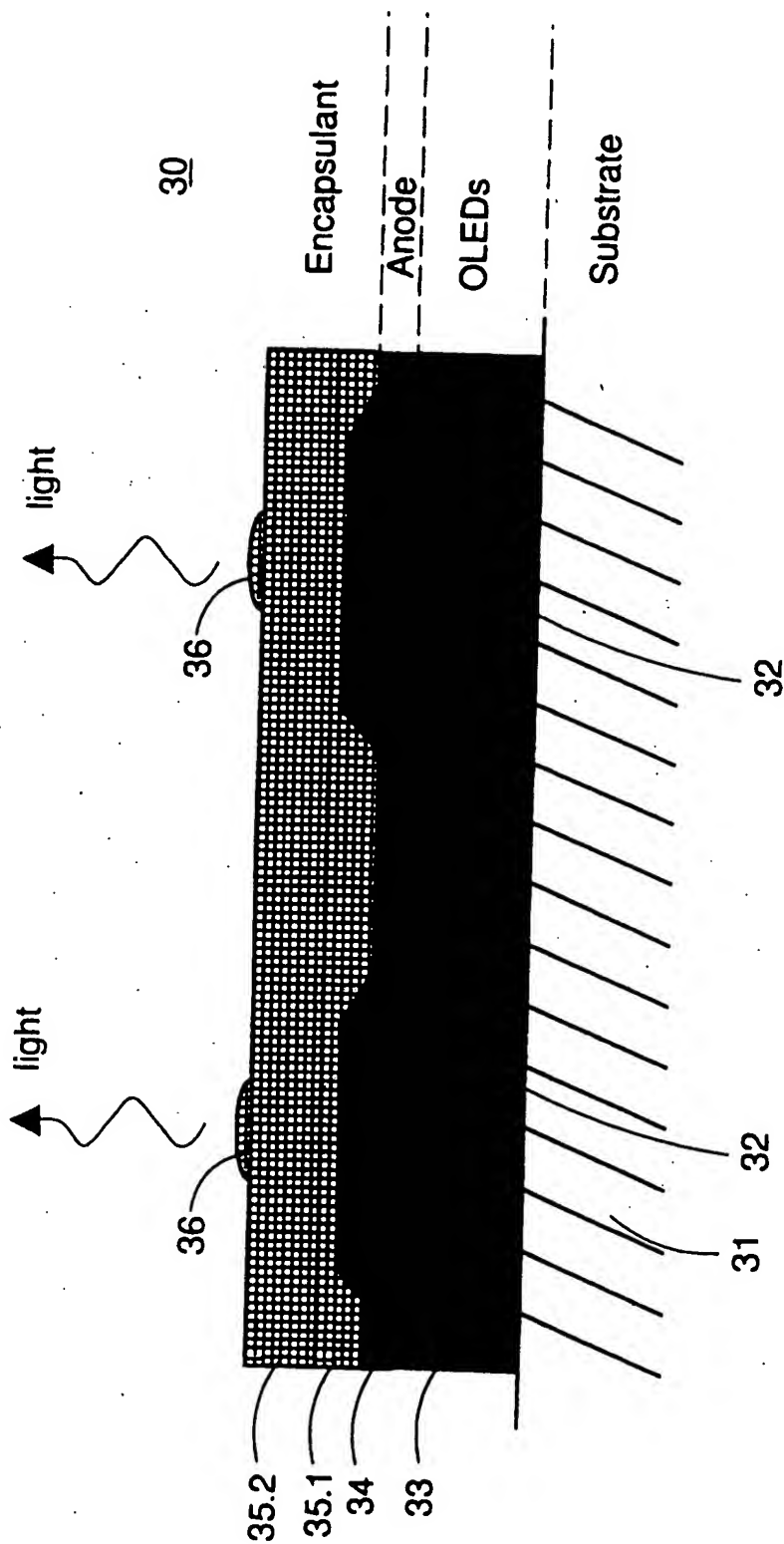


FIG. 3

3/4

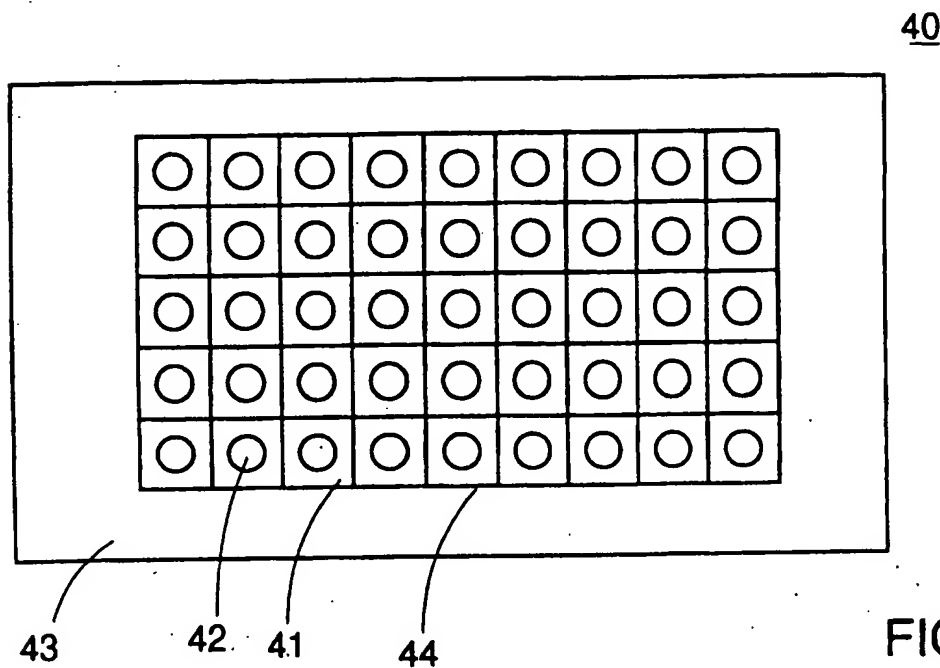


FIG. 4

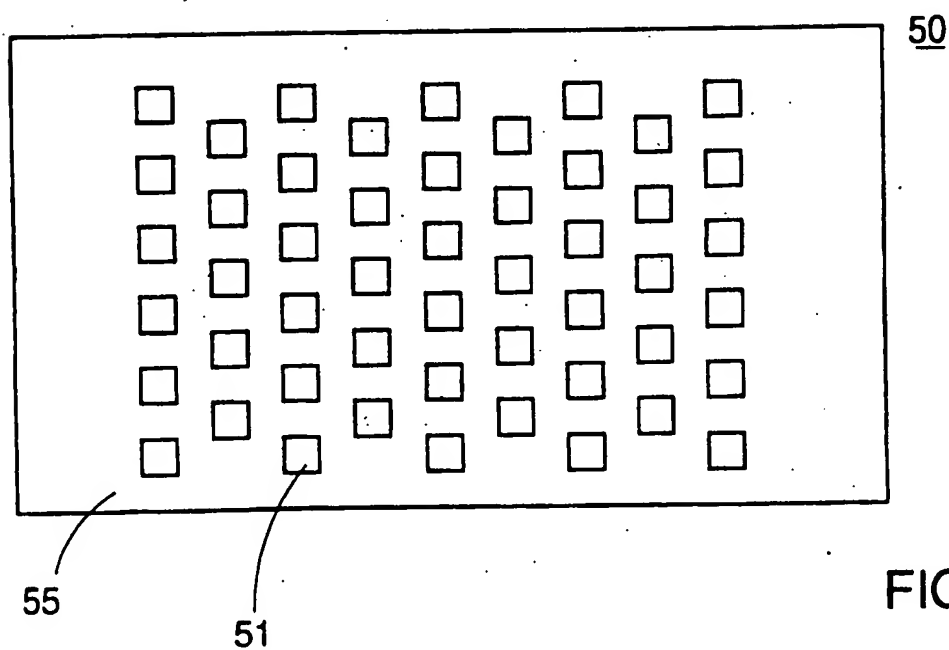


FIG. 5

4/4

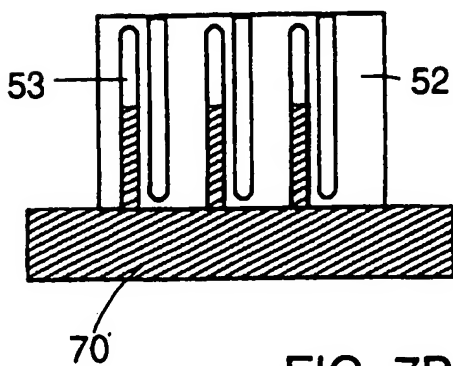
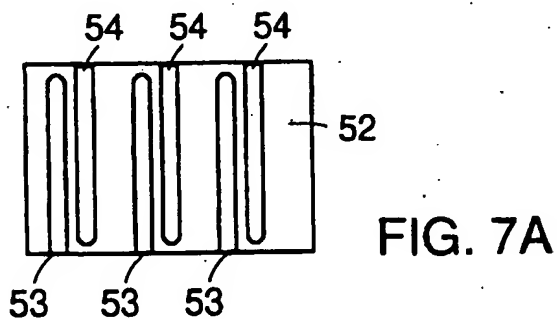
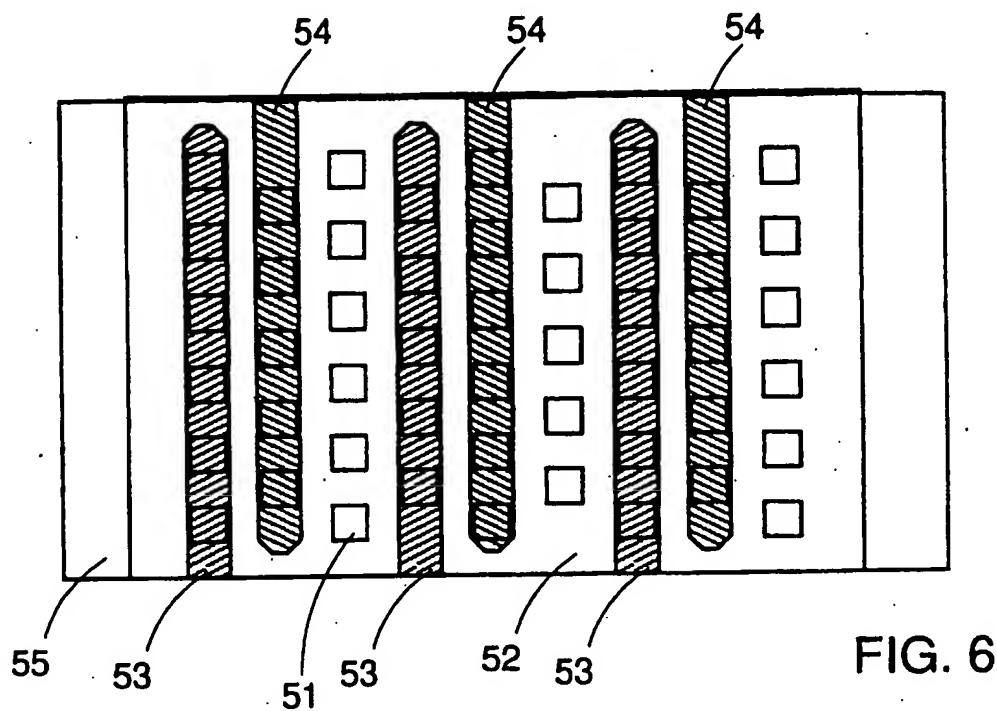


FIG. 7B

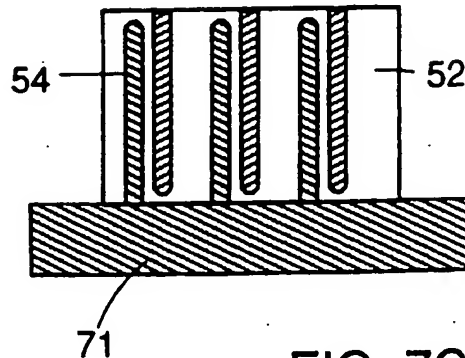


FIG. 7C

INTERNATIONAL SEARCH REPORT

Intern: J Application No
PCT/IB 96/00665

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H05B33/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0 554 569 A (EASTMAN KODAK CO) 11 August 1993 see page 3, line 8 - page 4, line 8; figure 1	1-4,6,7, 11,13
A	see page 3, line 8 - page 4, line 8; figure 1	3,9,18
Y	US 4 405 208 A (SHIRAI YOSHIHIRO) 20 September 1983 cited in the application see column 1, line 3 - column 2, line 18; claim 1; figures 1,2	1-4,6,7, 11,13
A	see column 7, line 1-46 see column 1, line 3 - column 2, line 18 --- -/--	18



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- *A* document member of the same patent family

Date of the actual completion of the international search

27 June 1997

Date of mailing of the international search report

18.07.97

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Felgel-Farnholz, W-D

INTERNATIONAL SEARCH REPORT

Intern. Application No
PCT/IB 96/00665

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 514 627 A (LOWERY CHRISTOPHER H ET AL) 7 May 1996 see column 2, line 12 - column 3, line 4; claims 1,3,6; figure 2 see abstract ---	1,2,4, 11,18
A	US 4 417 174 A (KAMIJO YOSHIMI ET AL) 22 November 1983 see column 1, line 10 - column 2, line 39; figure 1 see abstract ---	1,7,11, 18
A	US 5 068 157 A (WON SONG) 26 November 1991 see column 1, line 14 - column 2, line 63; claims 1,2,5; figures 1,2 ---	1,11,18
A	US 5 294 869 A (TANG CHING W ET AL) 15 March 1994 see abstract; claim 1; figures 1-4 ---	1,3,7-9, 11,14, 15,17,18
A	EP 0 328 120 A (SHINETSU CHEMICAL CO) 16 August 1989 see page 4, line 56 - page 5, line 14; claim 7; figure ---	1,11,18
A	US 5 492 981 A (HOEHN KLAUS ET AL) 20 February 1996 see abstract ---	1,11,18
A	US 5 063 102 A (LEE CHI-LONG ET AL) 5 November 1991 cited in the application see abstract; claims 1,6 ---	1,2,11, 18
A	MOLECULAR CRYSTALS AND LIQUID CRYSTALS, vol. 253, 1994, GORDON AND BREACH SCIENCE PUBLISHERS S.A., US, pages 143-150, XP002033530 YOSHIHARU SATO; HIROYUKI KANAI: "Stability of Organic Electroluminescent Diodes" cited in the application see page 143 - page 144; figure 1 -----	1,11,18

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/IB 96/00665

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0554569 A	11-08-93	CA 2085445 A JP 5258862 A	01-07-93 08-10-93
US 4405208 A	20-09-83	JP 56111833 A	03-09-81
US 5514627 A	07-05-96	DE 4441905 A JP 7221350 A	27-07-95 18-08-95
US 4417174 A	22-11-83	JP 1230371 C JP 57063797 A JP 59003839 B JP 1229875 C JP 57101377 A JP 59003840 B US 4455324 A	19-09-84 17-04-82 26-01-84 19-09-84 23-06-82 26-01-84 19-06-84
US 5068157 A	26-11-91	NONE	
US 5294869 A	15-03-94	CA 2085318 A DE 69217470 D EP 0550062 A JP 5258859 A	01-07-93 27-03-97 07-07-93 08-10-93
EP 0328120 A	16-08-89	JP 1204393 A JP 8006087 B AU 2975289 A CA 1316686 A DE 68922420 D DE 68922420 T KR 9703239 B US 4882517 A	16-08-89 24-01-96 10-08-89 27-04-93 08-06-95 19-10-95 15-03-97 21-11-89
US 5492981 A	20-02-96	DE 4328466 C EP 0641826 A JP 7097433 A	13-04-95 08-03-95 11-04-95
US 5063102 A	05-11-91	CA 2029970 A EP 0430273 A JP 3227365 A	02-06-91 05-06-91 08-10-91